

Comparison of surgical outcomes of patients with vascularized or nonvascularized grafting in scaphoid nonunion surgery

Comparison of surgical outcomes grafting in scaphoid nonunion surgery

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Abstract

Aim: We compare the results of scaphoid fracture nonunion surgeries involving vascularized bone grafting (VBG) or nonvascularized bone grafting (NVBG).
Materials and Methods: This study was conducted with 34 patients with scaphoid fracture nonunion. Patients were divided into two groups, including those treated with VBG (n = 17) and those treated with NVBG (n = 17).
Results: Union rates did not differ significantly between the VBG and NVBG groups (p = 0.335). There was also no significant difference in visual analogue scale (VAS) or Disabilities of the Arm, Shoulder, and Hand (DASH) scores between the two groups. However, Mayo scores were significantly higher in the VBG group compared to the NVBG group (79.41 ± 13.57 versus 64.41 ± 25.67; p = 0.027).
Discussion: In this study, union rates in patients who underwent scaphoid fracture nonunion surgery with VBG or NVBG were compatible with the literature, and both methods were found to be reliable. There was no statistical difference between them.

Keywords

scaphoid, nonunion, vascularized bone graft, nonvascularized bone graft

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This study was approved by the Ethics Committee of Gazi Yaşargil Training and Research Hospital (Date: 2023-05-26, No: 410)

Introduction

Scaphoid fractures are the most common type of carpal bone fracture, accounting for 60% of all carpal bone fractures. Injuries of the scaphoid bone are not easy to diagnose or treat because of the bone's complex 3-dimensional structure. The scaphoid bone anatomically forms a connection between the proximal and distal carpal rows and the distal radius; therefore, it is subjected to high mechanical stress [1,2]. Approximately 80% of the scaphoid surface is covered by cartilage. The blood supply comes from the dorsal carpal branch of the radial artery, which accounts for 70-80% of the blood supply to the scaphoid and enters the bone from the distal to proximal direction. The superficial palmar branch of the radial artery provides 20-30% of the blood supply to the scaphoid, primarily to the distal scaphoid. Therefore, the proximal scaphoid has poor blood supply, contributing to its longer healing time and higher nonunion rate [3].

Nonunion after scaphoid fractures occurs in 2-15% of cases but may reach rates of 30% when the fracture is located at the proximal pole. Other risk factors include avascular necrosis at the proximal pole, unreduced or unstable fracture, a delay of more than 4 weeks in the treatment of the fracture, and active smoking [4]. Despite the many studies conducted to date, there is no consensus on the optimal treatment of scaphoid nonunion. The general tendency in treatment is a combination of bone grafting and internal fixation [5]. However, there are different opinions on the choice of vascularized bone grafting (VBG) versus nonvascularized bone grafting (NVBG). For example, VBG has been reported to be a better treatment option because of its faster healing process, shorter immobilization time, and higher chance of stability due to the activity of living cells that provide nutrients to the bone structure [6,7]. However, VBG is technically more difficult than NVBG, requires microsurgical techniques, and results in long surgical time and donor site morbidity [8].

The aim of this study was to compare the treatment results of cases of scaphoid nonunion treated surgically with VBG or NVBG.

Materials and Methods

Institutional and researcher approval was obtained for this study. Ethical approval was granted by the ethics committee of the hospital where all imaging and patient procedures were performed in a single center. The study had no financial incentive. All procedures were performed in accordance with the ethical rules and principles of the Declaration of Helsinki.

In this retrospective study, patients over 18 years of age with at least 1 year of follow-up at a Level 1 trauma center between September 2020 and March 2023 with a diagnosis of scaphoid nonunion in the upper extremity were retrospectively analyzed. A total of 34 patients were included in the study, 32 of whom were male, while 2 were female. Eight patients who could not be reached for follow-up were excluded. All patients were diagnosed by physical examination followed by direct radiographs. After the diagnosis, each patient was evaluated with 3-dimensional computed tomography to determine the fracture structure and fracture fragment size. All patients underwent preoperative magnetic resonance imaging for the

diagnosis of avascular necrosis. Exclusion criteria were previous wrist surgery, carpal bone fractures other than those of the scaphoid, neurological or systemic inflammatory diseases, and severe arthritis. Patients who met the criteria were called to the hospital for follow-up, and necessary tests and examinations were performed. These patients were divided into two groups, which respectively included 17 patients treated by VBG from the volar carpal artery and 17 patients treated by NVBG from the distal radius. The demographic characteristics, time from fracture to surgery, smoking status, and Herbert and Fisher classification of the patients were recorded preoperatively. All patients were evaluated postoperatively and at 1, 3, 6, and 12 months with wrist radiographs. The radiologically confirmed formation of at least 3 cortical calluses at the fracture line was considered evidence of consolidation of the fracture. All surgical procedures were performed by the same senior surgeon. The reason why such a high number of patients can be treated by a single hand surgeon is that a single doctor is the only hand surgeon who treats 5 million people in 6 cities. Preoperative and postoperative evaluations were performed by the same specialist.

Surgical Techniques

NVBG Surgical Technique

With regional block anesthesia, the extremity was drained of blood with an elastic bandage, and the tourniquet applied to the arm was inflated to 100 mmHg higher than the systolic blood pressure. The flexor carpi radialis sheath was opened with a volar incision, and the tendon was excised from the ulnar aspect. The wrist capsule was accessed, and the joint capsule was opened with a Z incision from the volar side. The scaphoid fracture was reached, the fibrotic and sclerotic nonunion tissue along the fracture line was removed with the help of a curette and burr, and the blood-supplying bone tissues were accessed. The nonvascularized bone graft was then taken from the volar aspect of the radius proximal to the incision and placed on the fracture line, and the fracture was fixed with one headless compression screw (3.5-mm headless screw, Zimed, Ankara, Turkey) directed from the distal to the proximal under fluoroscopic control. The joint capsule was closed. The skin was then closed, and the operation was terminated with a short arm splint.

VBG Surgical Technique

With regional block anesthesia, the tourniquet applied to the arm was inflated to 100 mmHg higher than the systolic blood pressure without draining the blood from the extremity. Under 2.5-fold loop magnification, the flexor carpi radialis sheath was opened with a volar incision, and the tendon was excised from the ulnar aspect. The wrist capsule was accessed, and the joint capsule was opened with a Z incision from the volar side. The scaphoid fracture was reached, the fibrotic and sclerotic nonunion tissue along the fracture line was removed with the help of a curette and burr, and the blood-supplying bone tissues were accessed. The volar carpal artery, running parallel to the wrist joint, was then identified from the proximal part of the incision, from the volar aspect of the radius to the distal of the pronator quadratus muscle. The artery was followed toward the ulnar side, and the vascular bone graft was removed with the help of thin osteotomes from the area in which it entered the

radius on the ulnar side (Figure 1). The proximal pedicle was carefully lifted over the bone and dissected sufficiently to reach the fracture line. The vascular bone graft was placed on the fracture line and, under fluoroscopic control, the fracture was fixed with one headless compression screw (3.5-mm headless screw, Zimed) directed from the distal to proximal (Figure 2,3). The joint capsule was closed. The skin was then closed, and the operation was terminated with a short arm splint. Postoperative union time, nonunion status, cast duration, postoperative 1-year visual analogue scale (VAS) score, modified Mayo wrist score [9], and Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire score [10] were analyzed for all patients. The Mayo wrist score assesses the presence and intensity of pain, range of motion, and hand grip strength, expressed as percentage points compared to the uninjured hand, as well as functional status in terms of activity performance. Outcome scoring is as follows: 90-100, excellent; 80-90, good; 60-80, satisfactory, and < 60, poor. The DASH Questionnaire consists of 30 questions that evaluate the patient's ability to perform daily activities in the past week, regardless of which hand he or she uses. Scores range from 0, indicating no disability, to 100, indicating complete disability. Postoperatively, patients received short arm casts, which were removed at week 8. Finger movements were performed until the casts were removed. Rehabilitation was started after cast removal. In rehabilitation, passive assisted wrist movements were performed until radiological union was confirmed, and then active movements were started after radiological union. Stretching exercises were performed with a physiotherapist by patients with restricted mobility.

Statistical Evaluation

The statistical analysis of this study was performed with NCSS (Number Cruncher Statistical System) 2007 Statistical Software (NCSS, LLC, Kaysville, UT, USA). In the evaluation of the data, in addition to the use of descriptive statistical methods with mean, standard deviation (SD), median, and interquartile range (IQR) values, the distribution of variables was examined with the Shapiro-Wilk normality test, the independent t-test was used in the comparison of paired groups of normally distributed variables, the Mann-Whitney U test was used in the comparison of paired groups of variables that did not show normal distribution, and the Chi-Square and Fisher exact test were used in the comparison of qualitative data. Results were evaluated at a significance level of $p < 0.05$.

Ethical Approval

This study was approved by the Ethics Committee of Gazi Yaşargil Training and Research Hospital (Date: 2023-05-26, No: 410).

Results

Of the 34 analyzed patients, 32 (94%) were male and 2 (6%) were female. The ages of the patients ranged between 18-37 years, and the mean age ($\pm$ SD) was 22.71 ± 4.92 years in the VBG group and 25.47 ± 5.40 years in the NVBG group. There were no significant differences between the groups in terms of demographic characteristics ($p > 0.05$), as shown in Table 1. The mean delay between fracture and surgery was similar between the groups (8.24 ± 3.11 in the VBG group and 9.06

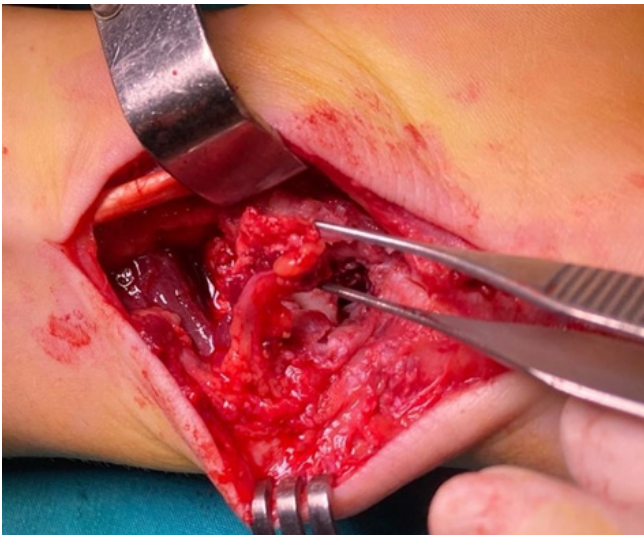


Figure 1. Pedicle osteosseous graft harvested from the area marked with a circle at the distal radius



Figure 2. Fluoroscopy image of fixation with vascularized graft AP



Figure 3. Fluoroscopy image of fixation with vascularized graft, lateral

Table 1. Comparison of patients divided into vascularized and nonvascularized graft groups

		Vascularized graft group		Cancellous graft group		p
Age	Avr±SS	22,71 ± 4,92		25,47 ± 5,40		0,128*
Sex	Male	17	100,00%	15	88,24%	0,485‡
	Female	0	0,00%	2	11,76%	
Herbert Fisher Classification	D1	5	29,41%	5	29,41%	1+
	D2	12	70,59%	12	70,59%	
Fracture-Surgery time (month)	Avr±SS	8,24 ± 3,11		9,06 ± 5,33		0,862‡
	Median (IQR)	8 (6-10)		7 (5-13,5)		
Union	Absent	1	5,88%	4	23,53%	0,335‡
	Available	16	94,12%	13	76,47%	
Union time (month)	Avr±SS	5,63 ± 1,31		6,23 ± 1,42		0,496‡
	Median (IQR)	6 (4-7)		6 (5,5-6,5)		
Casting time (day)	Avr±SS	53,24 ± 11,85		48,82 ± 10,83		0,157‡
	Median (IQR)	60 (47,5-60)		45 (45-60)		
Smoking	Absent	9	52,94%	7	41,18%	0,492+
	Available	8	47,06%	10	58,82%	
Mayo EBS score	Avr±SS	79,41 ± 13,57		64,41 ± 25,67		0,027‡
	Median (IQR)	80 (75-87,5)		75 (45-82,5)		
Quick DASH Score	Avr±SS	73,12 ± 14,38		61,53 ± 24,63		0,214‡
	Median (IQR)	76 (68,5-83,5)		71 (42-78,5)		
VAS	Avr±SS	2,59 ± 1,84		3,47 ± 2,83		0,637‡
	Median (IQR)	2 (2-3)		2 (2-5)		

*Independent t test, ‡Mann Whitney-U Chi Square test, †Fisher's Reality test

± 5.33 in the NVBG group; $p > 0.05$). The Herbert-Fisher class was D1 for 5 patients and D2 for 12 patients in the VBG group; similarly, it was D1 for 5 patients and D2 for 12 patients in the NVBG group. No significant differences were found between the groups in terms of smoking status, cast use, or follow-up duration.

A total of 29 patients achieved union. Union was not achieved by 1 patient (5%) in the VBG group and 4 patients (23%) in the NVBG group. Although union was achieved by more patients in the VBG group, the difference between the groups was not statistically significant ($p > 0.05$). No complications were encountered in either group. The results of the patients who had achieved union at the end of the follow-up period are shown in Table 1. There were no significant differences between the groups in terms of VAS or DASH scores ($p > 0.05$). For the Mayo wrist score, the mean was 79.41 ± 13.57 and the median (IQR) was 80 (75-87.5) in the VBG group compared to 64.41 ± 25.67 and 75 (45-82.5) in the NVBG group, respectively. Thus, Mayo wrist scores were statistically significantly higher in the VBG group than the NVBG group ($p = 0.027$). No significant complications such as infection, loosening/dislocation of screws, loss of fracture reduction, or graft failure were observed during treatment.

Discussion

According to the data obtained in our study, the vascularity of the bone graft does not have a significant effect on the results of scaphoid fracture nonunion surgery. However, VBG dissection is technically more difficult and requires surgical experience. In these cases, dissection must be performed using special equipment such as a loop or microscope. In addition, even if the graft is placed with a pedicle, it is questionable how long a

thin pedicle can maintain the blood supply after wound closure. Surgeries with NVBG are technically easier. There are also no concerns regarding the preservation of graft vascularity.

Various treatments for scaphoid fractures have been described according to anatomical localizations and stages. In the present study, we compared the results of scaphoid fracture surgery with volar radial artery flaps and cancellous grafts from the distal radius. No clinical or functional differences were found among our patients operated on for the nonunion of scaphoid fractures, other than the Mayo wrist score. We do not think that the difference is significant. The similar results for the union observed in our patient groups are consistent with those reported in the literature. In our study, the union rates in the VBG and NVBG groups were 94% and 76%, respectively; however, no significant difference was observed in the healing process.

Different results have been reported in the literature in comparisons of scaphoid surgeries performed with VBG and NVBG. In a study of 73 patients, Hirche et al. [11] obtained union in 21 of 28 patients (75%) in the vascularized graft group and in 37 of 45 patients (82%) in the nonvascularized group, reporting no difference between the groups. In a study that included 31 patients, Aibinder et al. [12] obtained a union rate of 79% in patients with vascularized grafts and 71% in patients with nonvascularized grafts from the iliac wing. They found no significant difference between these groups. Matic et al. [13] compared xenografts and vascularized grafts in a study of 30 patients, obtaining union in 13 of 15 patients (86.7%) in the vascularized group and 12 of 15 patients (80%) in the xenograft group. They found no significant difference between the groups. Delamarre et al. [14] reported good union rates in all subgroups of their study, which included a total of 60 patients, and found no difference between the groups. In an

older study from 2008, Kawamura et al. [15] reported that the use of vascularized grafting increased the union rate and speed. There are many studies and meta-analyses in the literature on scaphoid fractures, and many recent studies have reported no difference in outcomes when different types of grafts are used. However, some studies have reported that union rates are higher with VBG. As a more objective evaluation, Baamir et al. [8] reported no difference between grafting methods in their umbrella review study. In our study, we did not find any difference between grafting methods, and the fact that our results are compatible with those of previous studies in the literature increases the reliability of our findings. Although a better union rate may theoretically be obtained with vascularized grafts, these results show no difference between graft types.

In functional evaluations, Hirche et al. [11] found no difference between VBG and NVBG groups in terms of range of motion or Mayo wrist scores. In their meta-analysis, Zhang et al. [6] reported that although there were differences in union times between graft groups, a resulting difference in terms of functional outcome was not observed. From a functional point of view, it is not surprising to obtain similar functional results since the union rates and times are similar between the groups.

Limitations

The most important limitations of our study were its small sample size and retrospective nature. Another limitation was the lack of preoperative functional data and comparison with the respective extremity of the non-injured side. It was not possible to determine the exact time of fracture union because of the prolonged follow-up of the patients after 3 months. Furthermore, 8 patients being lost to follow-up is another limitation.

Conclusion

In this study, the union rates of patients who underwent scaphoid fracture nonunion surgery with VBG and NVBG were compatible with rates previously reported in the literature, and no difference was found between the two types of grafts. While Mayo wrist scores were better in the VBG group compared to the NVBG group, there were no differences between the groups in terms of VAS or DASH scores. Although our study has some limitations, having all surgeries performed by a single surgeon makes the study quite strong in terms of homogenizing the results of the groups. The promising surgical results of patients who underwent fracture surgery with both VBG and NVBG suggest that these are reliable treatment options for patients with scaphoid nonunion.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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